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ON THE AFFINITIES OF $\lambda 5778$ AND OTHER BROAD DIFFUSE INTERSTELLAR BANDS.

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1 INTRODUCTION

Of the twelve diffuse interstellar bands assigned to families by Krełowski & Walker (1987), ten are narrow (having FWHM of order a few Å) and two are broad (having FWHM of order a few tens of Å). Further, the two broad bands make up a family of their own. With over 100 bands now known (eg. Jenniskens 1992) it is of interest to determine whether all the broad bands are members of the same family. In this poster paper we review our recent findings from a study of the broad band at $\lambda 5778$ (McIntosh & Webster 1993a) and describe briefly our current work.

2 THE BROAD BAND AT 5778 Å.

We chose to examine the broad band at 5778 Å because of the quantity and quality of data that already existed in the literature. To investigate the affinity of that band with the bands of Family 1 we formed the ratio $W_\lambda(5778)/W_\lambda(4430)$. If the two bands belong to the same family then the ratio should be a constant from star to star and it should not be possible to find an independent variable with which the ratio is correlated. If, however, a variable is found which does produce a statistically significant correlation with the ratio of equivalent widths then the bands cannot be in the same family. We have previously shown that the ratio $W_\lambda(4430)/W_\lambda(5797)$ may be taken as an indicator of the balance between the competing physical and chemical processes which determine the relative abundance of the carriers and so this ratio was adopted as our independent variable (McIntosh & Webster 1993b). To test the affinity of the band at 5778 Å with the other families the procedure was repeated using the bands at 5780 and 5797 Å as being representative of Families 2 and 3 respectively. The result of the test, using measurements on 21 stars taken from Herbig (1975), is shown in Figure 1.

We find that statistically significant correlations result when the band at 5778 Å is tested against the bands of Families 1 and 2 but that there is no correlation with Family 3. We conclude that $\lambda5778$ is unlikely to be a member of Family 1 and so all the broad bands do not have their origin in a single carrier. Also $\lambda5778$ does not appear to be a member of Family 2 either but may be a member of Family 3. It appears that either a single carrier can be the origin of both broad and narrow bands or that the bands are produced by different carriers which exist in similar interstellar habitats. This latter possibility would require the introduction of a fourth family of bands.

3 THE BROAD BANDS AND THE FULLERANE THEORY.

According to a recent theory (Webster 1992, 1993a,b), the carriers of the diffuse interstellar bands are the fulleranes. The fulleranes (Paquette et al. 1983; Haufler et al. 1990) are the hydrides of the fullerenes whose archetype is the famous football-shaped molecule C_{60} (Kroto et al. 1985). Different bands are carried by different hydrides which are distinguishable one from another by the number of hydrogen atoms that they bear. A number of lines of enquiry have suggested that the carrier of Family 1 bears the greatest number of hydrogen atoms and that of Family 3 the least – with the carrier of the bands of Family 2 somewhere inbetween. The ratio $W_\lambda(4430)/W_\lambda(5797)$ is thus an indicator of the degree of hydrogenation of the molecule and increases as the average number of hydrogen atoms on a molecule in an interstellar population of fulleranes increases. As $W_\lambda(5778)/W_\lambda(4430)$ decreases as the degree of hydrogenation increases, it follows that the carrier of $\lambda5778$ must possess fewer hydrogen atoms than that of the carrier of $\lambda4430$.

It is suggested that the narrow and broad bands have their origins in two different types of electronic system that can exist on the molecule (Webster 1993b,c). The narrow bands are the transitions of the global system of conjugated bonds that extends over the surface of a lightly hydrogenated molecule. As the degree of hydrogenation increases, the global system is broken up into small, local systems of π-electrons and it is these local systems which are the carriers of the broad bands.

At first sight $\lambda5778$ appears to pose a problem since it is a broad band that seems to prefer a habitat occupied by lightly hydrogenated fulleranes. This could be resolved if there are two types of local system: a closed type, in which the sp^2-hybridized carbon atoms that carry the transition are completely penned in by the surrounding sp^3-hybridized hydrogenated carbon atoms, and an open type, in which the π-system is only partially surrounded but a neighbouring conjugated system completes the isolation. (An example of an open allyl radical has been found on lightly substituted C_{60} by Krusic et al. 1991.) If two forms of local system can exist in this way, $\lambda4430$ would have its origins in a closed system whereas $\lambda5778$ would have its origins in an open system.

4 CURRENT WORK.

It is an attractive feature of the fullerane theory that the proposal that the broad bands have their origins in local systems results in only a limited number of candidates to be the carriers. We are currently engaged in producing a large and homogeneous dataset of the seven broad bands at 4430, 4882, 5449, 5535, 5778, 6177 and 6314 Å with the aim of checking our results concerning $\lambda 5778$ and determining the number of carriers involved in their production. During our first observing run in July 1993 on the Jacobus Kapteyn Telescope at La Palma we obtained spectra from 13 target stars. A second observing trip is scheduled for July 1994 to enable us to obtain measurements from a similar number of different stars.

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Figure 1. Band ratios plotted against $\rho_{13} \equiv W_\lambda(4430)/W_\lambda(5797)$. (a) $\lambda5778/\lambda4430$ (b) $\lambda5778/\lambda5780$ (c) $\lambda5778/\lambda5797$.